EasyLiving

Creating a highly integrated computing experience

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Ubiquitous Computing group

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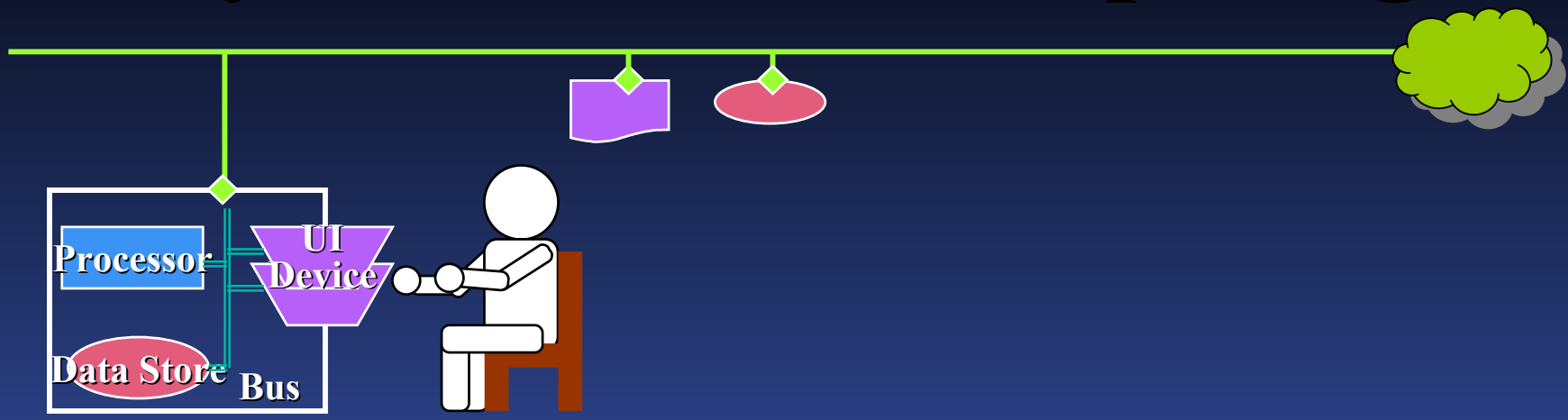
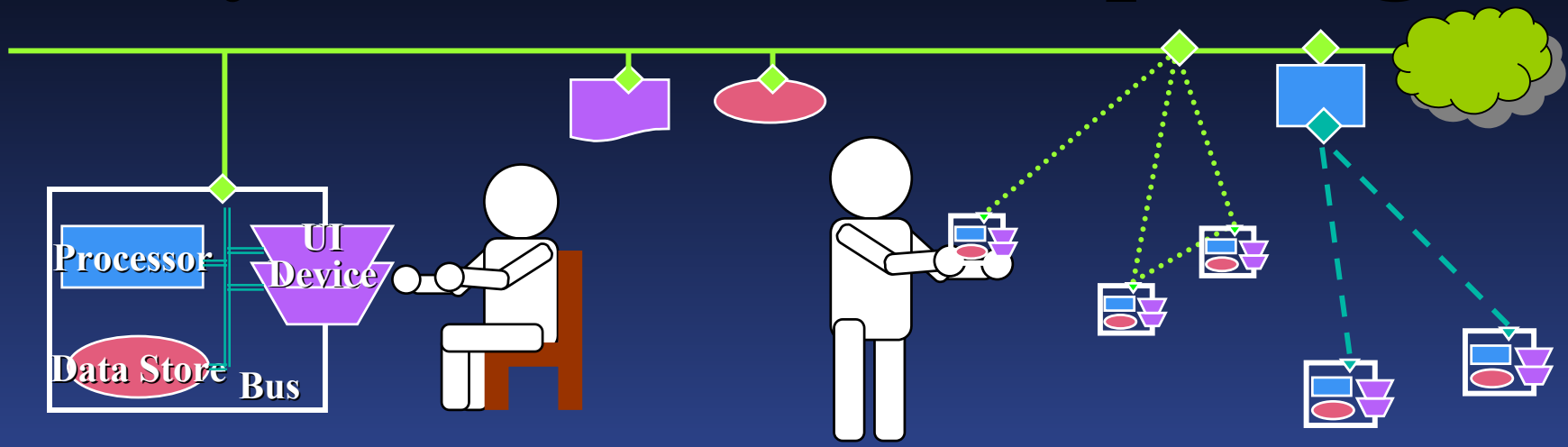
http://research.microsoft.com/easyliving/
//easyliving

Beyond Mobile Computing



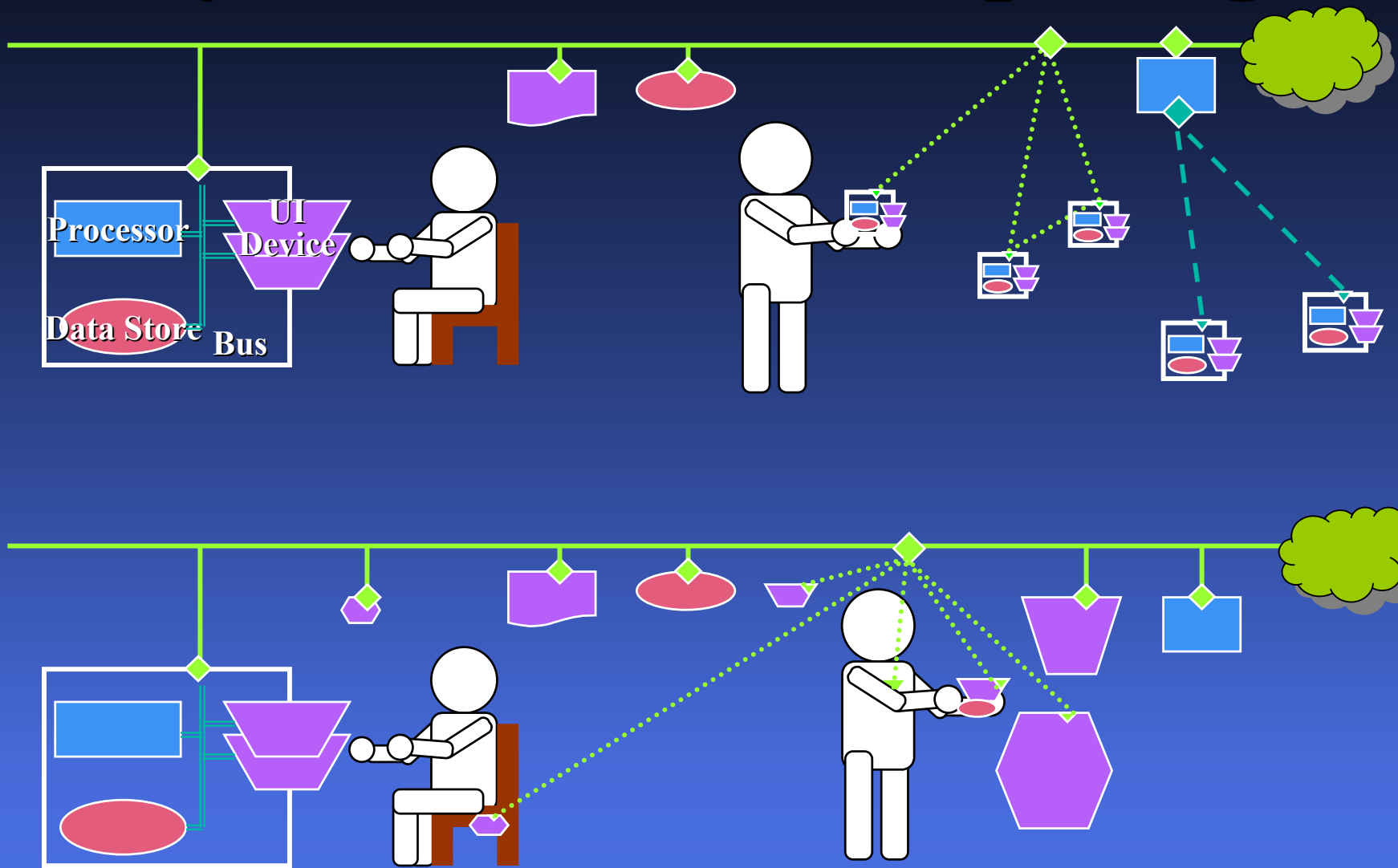
Desktop Computing

Beyond Mobile Computing



Mobile Computing

Beyond Mobile Computing



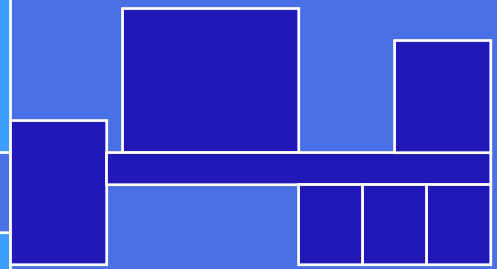
Highly Integrated Computing

Geometry At Multiple Scales

City / Zip Code -- deliver pizza

Campus: GPS / Cell phone
10m precision -- "locate building"

Building: Badge
1m precision
"locate printer"

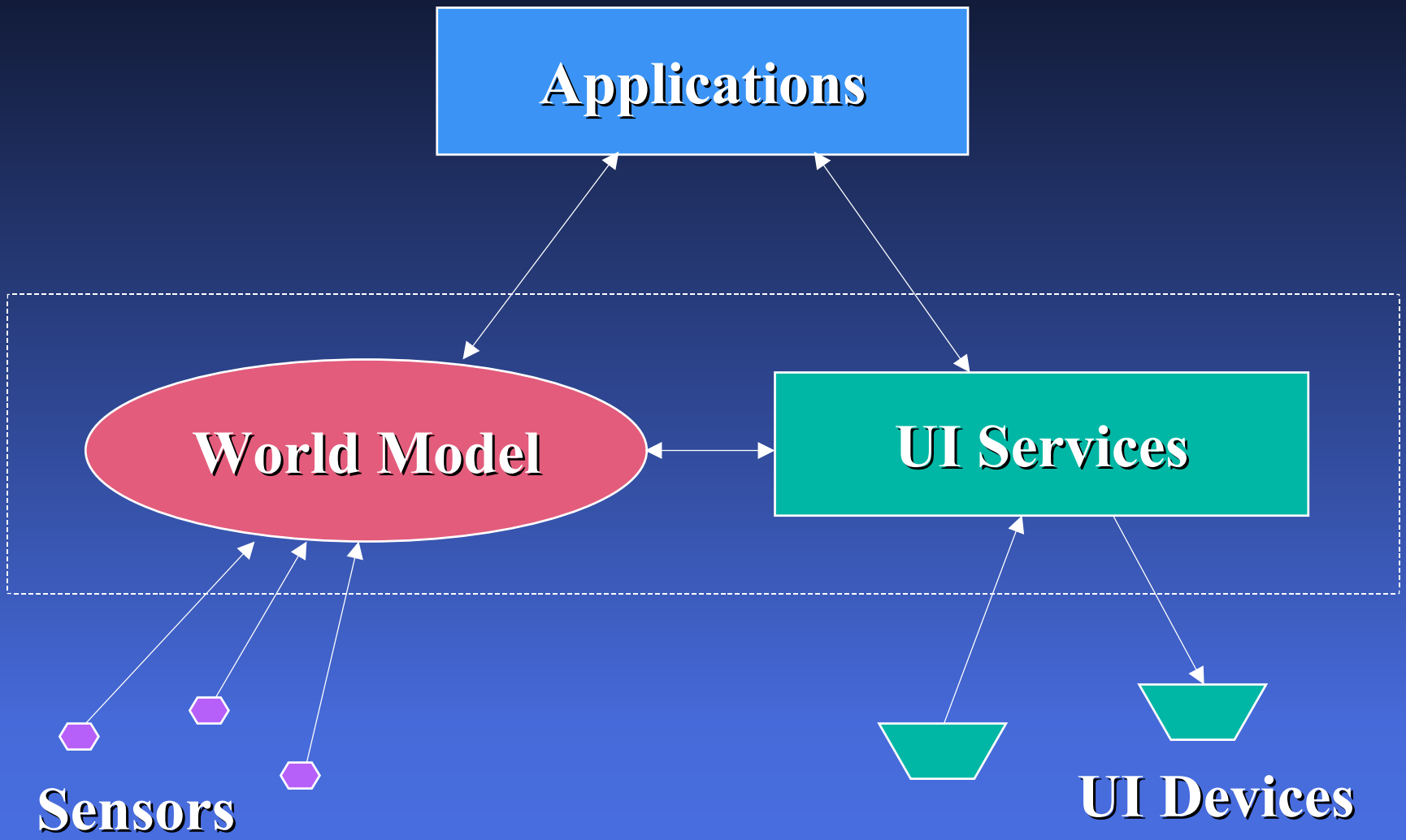


Rooms: Camera
10cm precision
"select UI device"

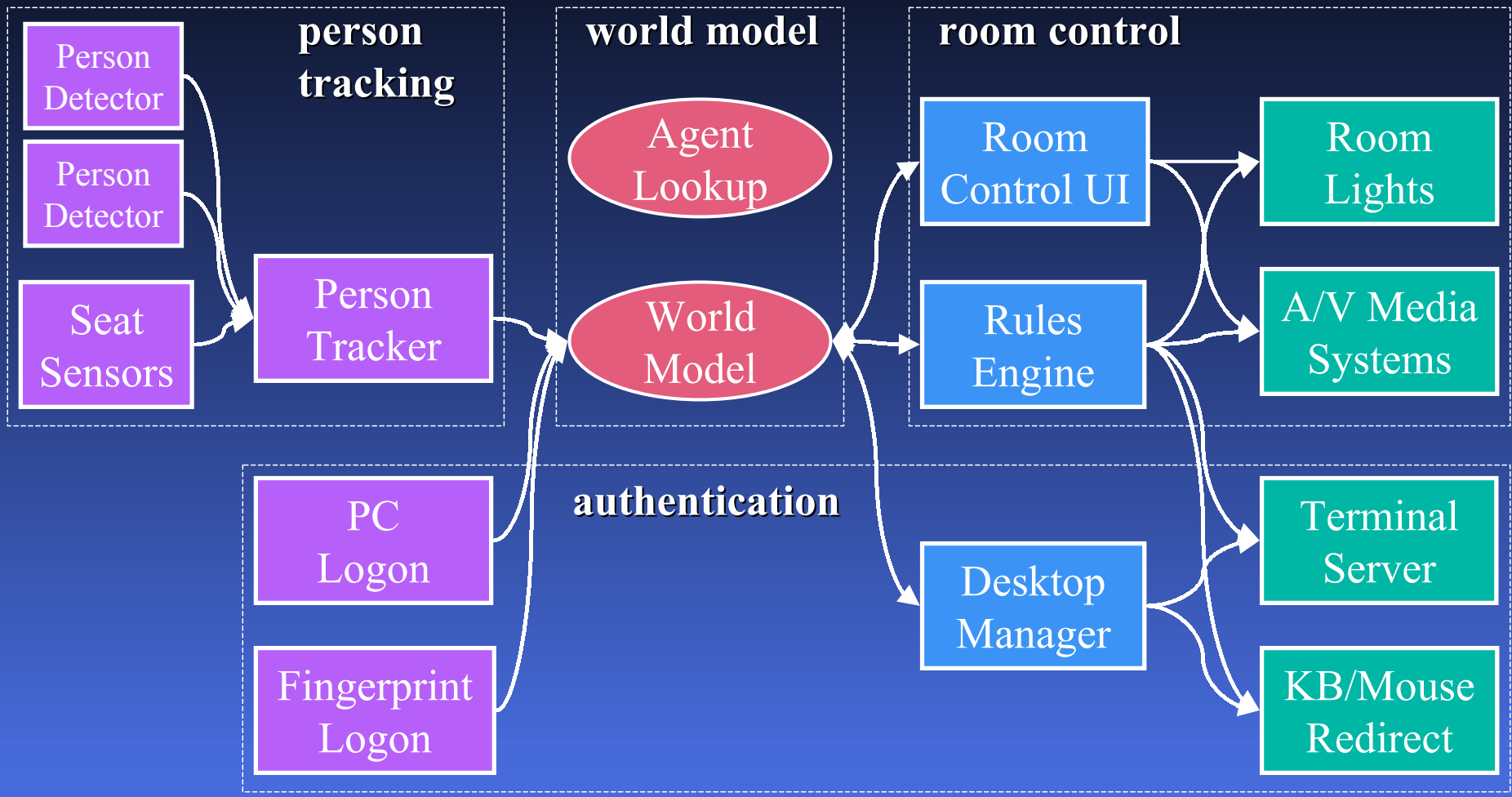
EasyLiving Demo

Progress report as of today

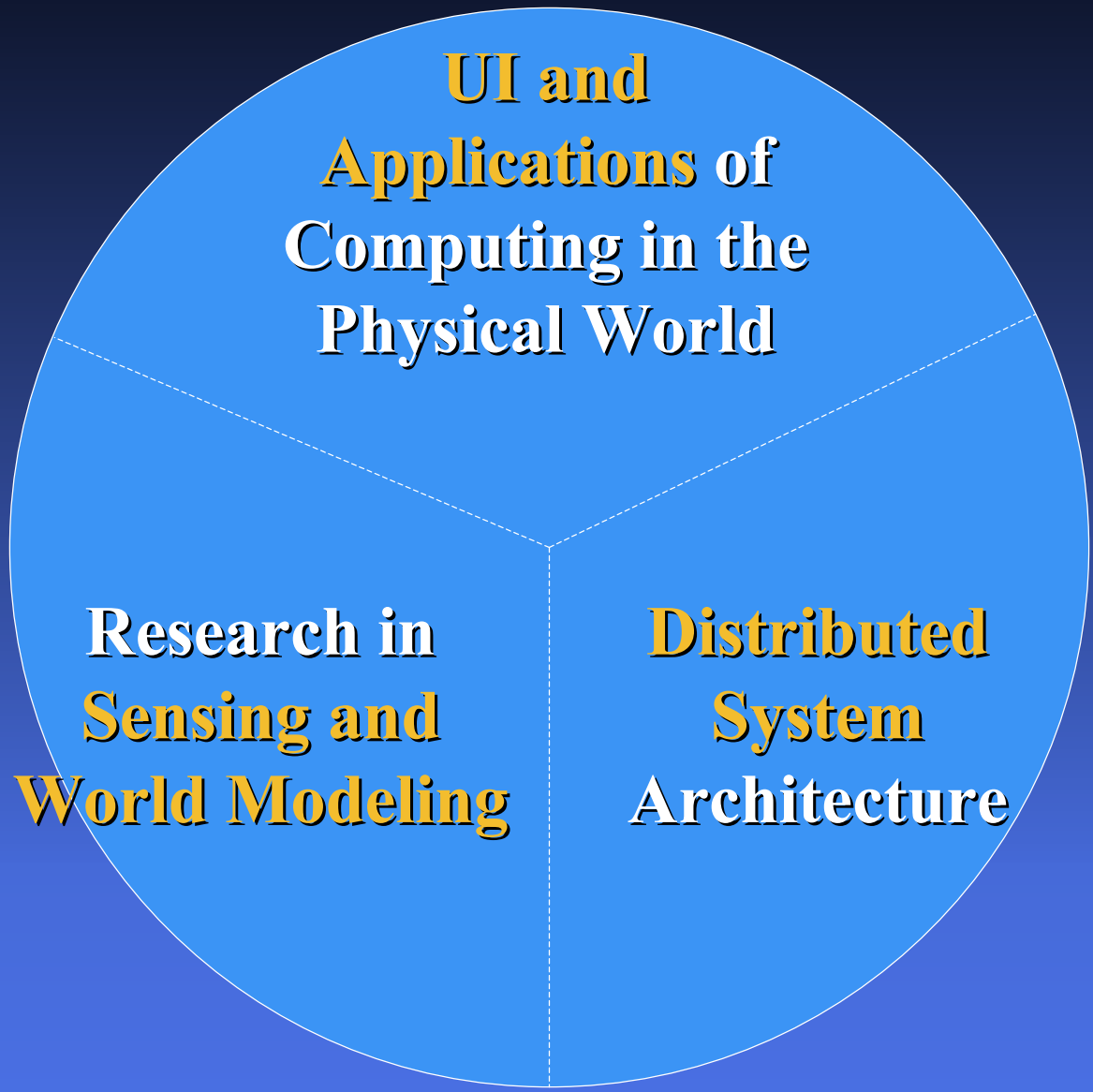
How To Integrate



The EasyLiving System



Elements of EasyLiving



Person Tracking in EasyLiving

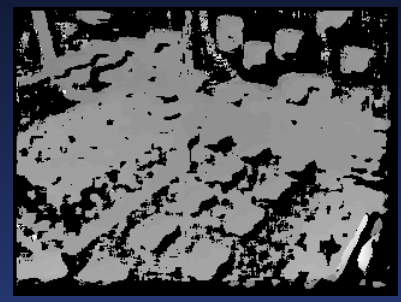
Person Detection

Stereo processing with commercial software

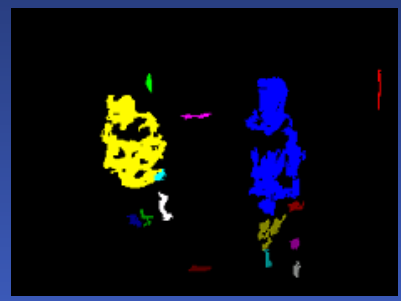
Background subtraction and person detection

Reports sent to central person tracker about 7 Hz

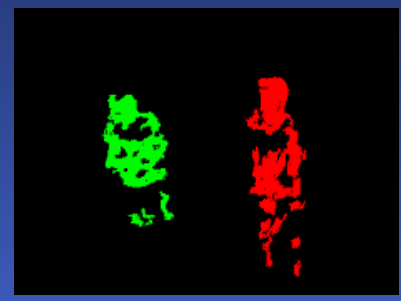
color



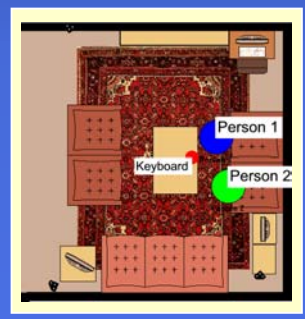
depth



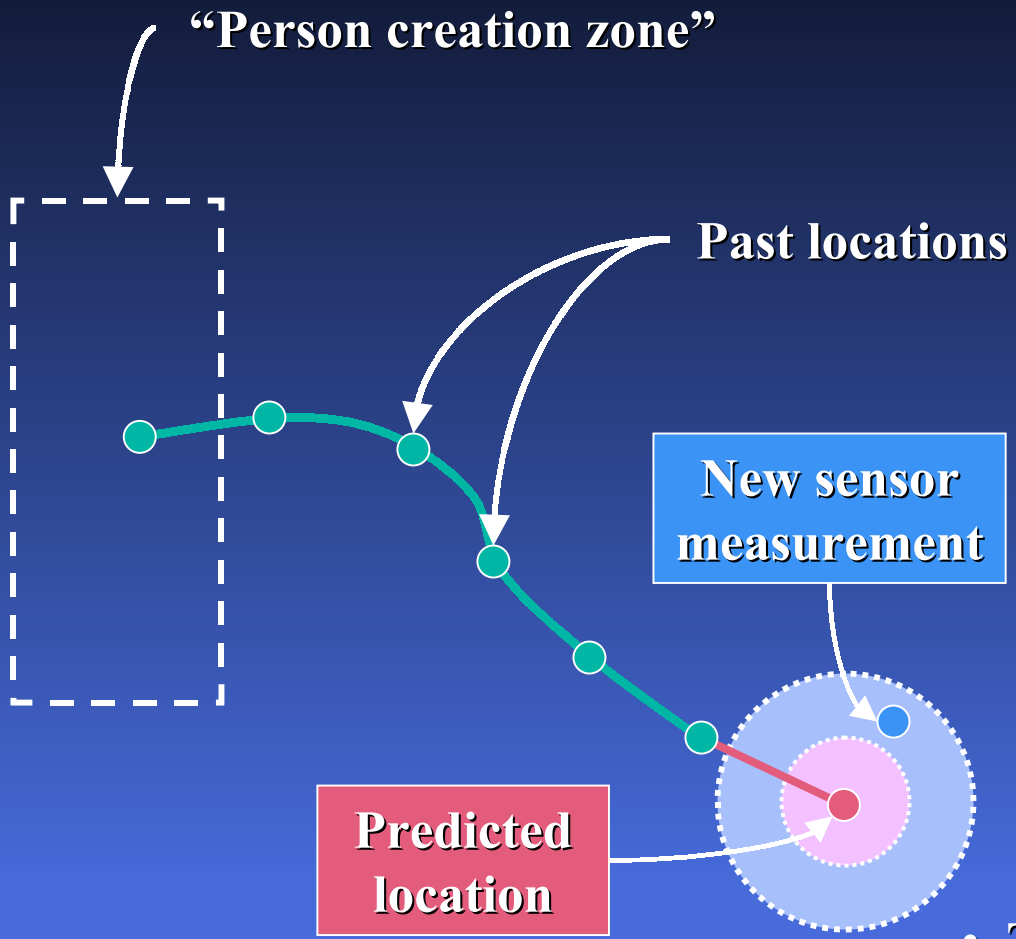
patches



people



Person Tracking

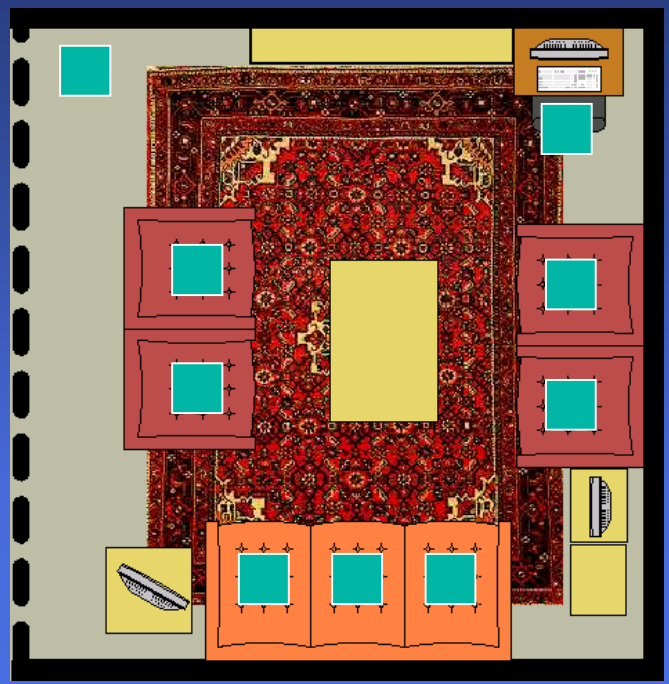


Process each new report from a sensor

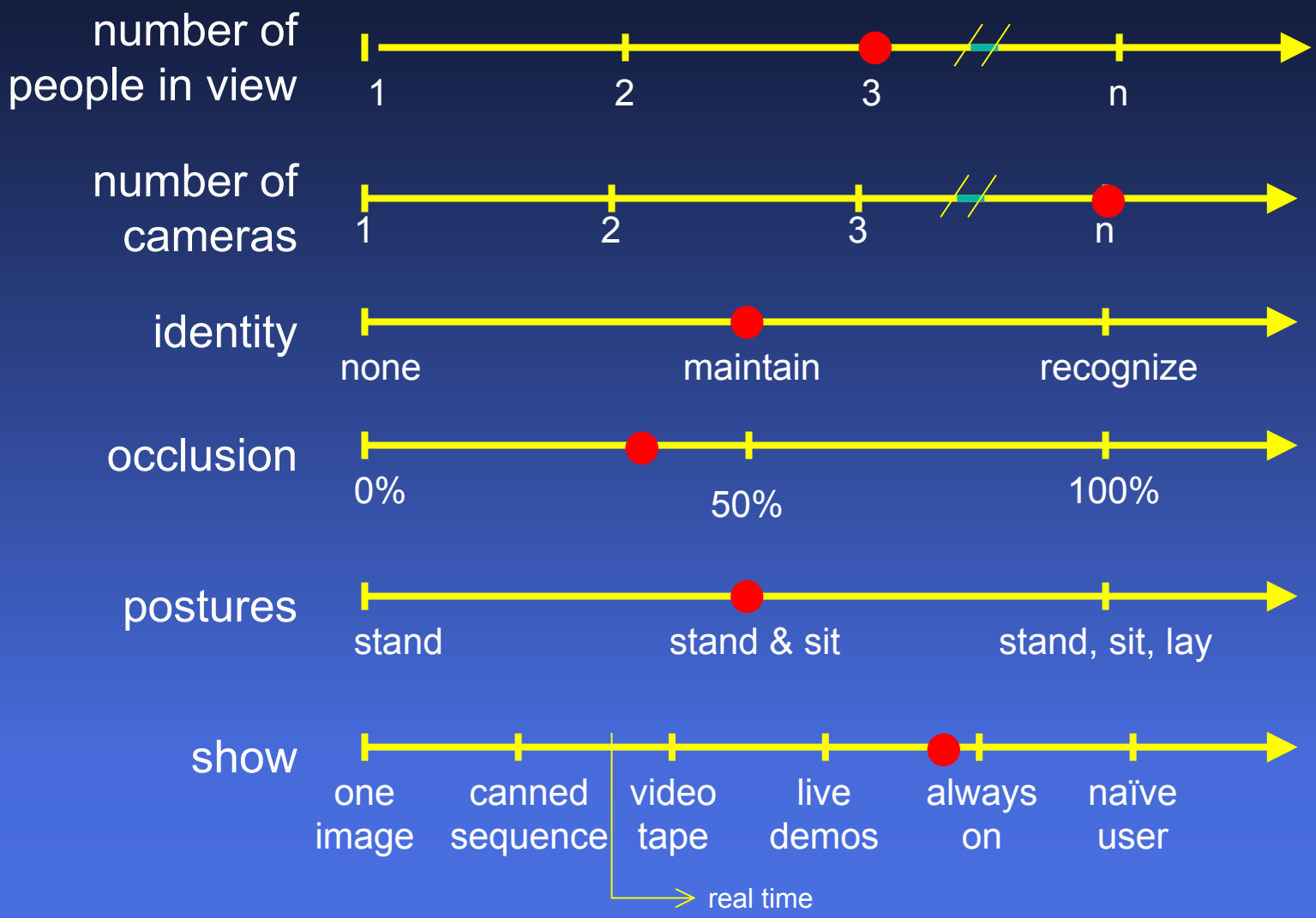
- Timeouts for unsupported tracks
- Nearby tracks "repel"

Seat / Floor Mat Sensors

- Additional information for person-tracking
- Distinguish stand v. sit
- Less invasive than cameras



EasyLiving Person Tracking



Camera Calibration

Image	World
(u_1,v_1)	$(x_1,y_1,0)$
(u_2,v_2)	$(x_2,y_2,0)$
…	…

Image	World
(u_1,v_1)	$(x_1,y_1,0)$
(u_2,v_2)	$(x_2,y_2,0)$
…	…

Image	World
(u_1,v_1)	$(x_1,y_1,0)$
(u_2,v_2)	$(x_2,y_2,0)$
…	…

Active Badges (Future)

- Badges for person tracking:
  - Larger area, less precision
  - Fusion via generic person tracker

- Ultrasound badges (AT&T) in lab use
- Diffuse-IR system from Arial Systems
- Signal strength from Wireless LAN??
- Bluetooth beacons?

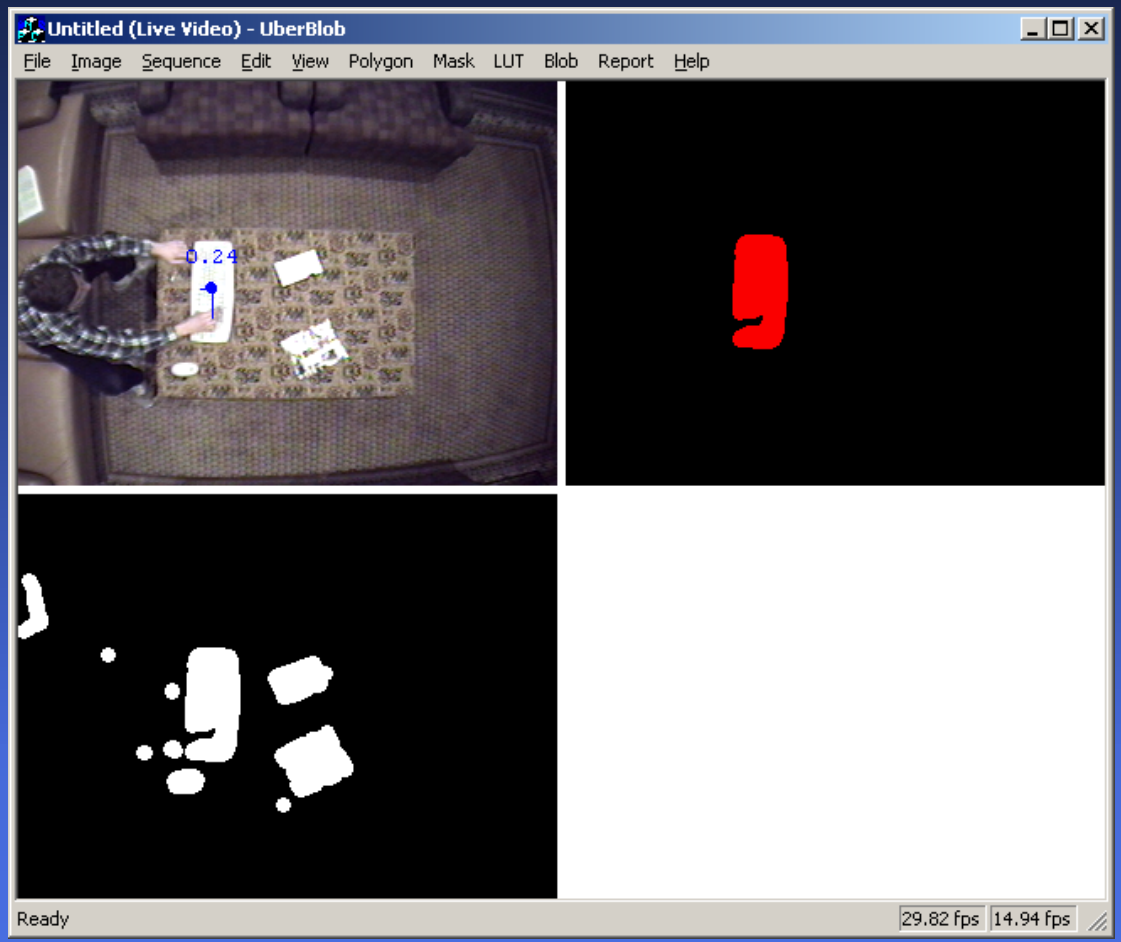
Keyboard Detection

Match color and approximate shape

1

2

3



World Model in EasyLiving

World Model

What is described?

- Rooms and doorways
- Computing devices
- Other things in the world
- People
  - Where they are
  - Who they are
  - Their preferences
  - What they are doing

The world model has many parts

Distributed Agent System

Agents represent services and things in the world:

- Properties in a SQL Server database
- Executable process

InConcert system provides services for agents:

- XML Messaging
- Invocation
- Heartbeat

How Agents Find Each Other

Specific knowledge:

- **Direct pointers** from other agents
- **Properties** in lookup service

Searching in real time:

- **Attribute** matching
- **Geometric** indexing

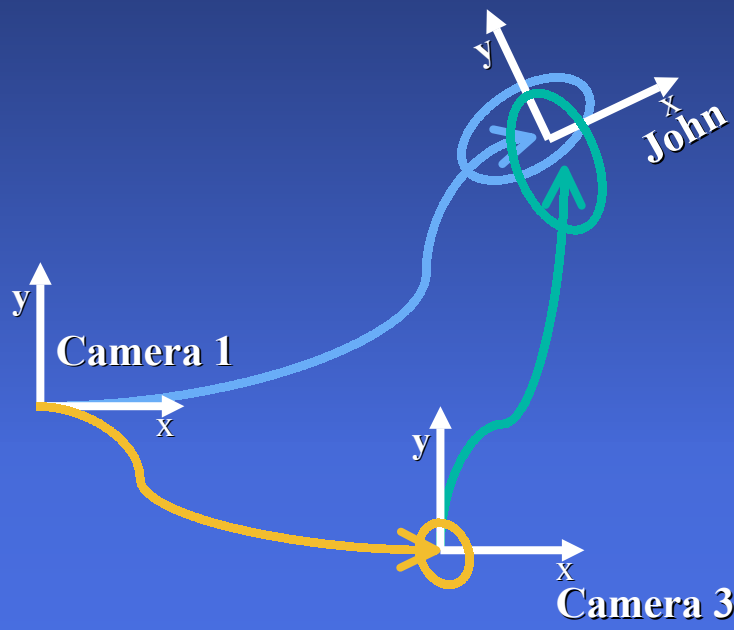
The Geometric Model

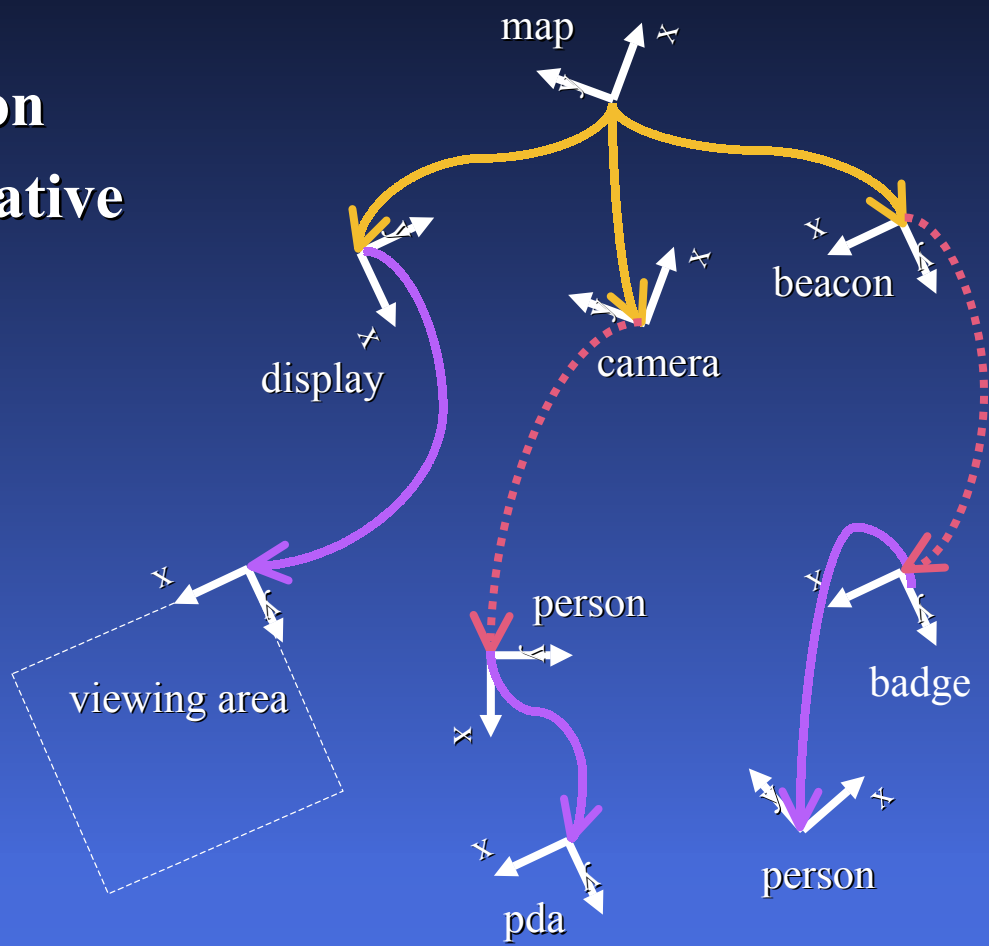
- Polygon objects and their relationships

Geometry in the Real World

Features:

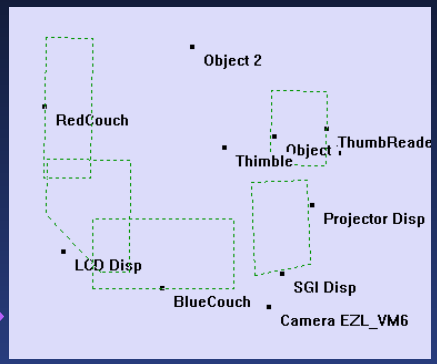
- **Uncertainty representation**
- **All measurements are relative**
- **Stored in SQL Server**





Using the Geometric Model

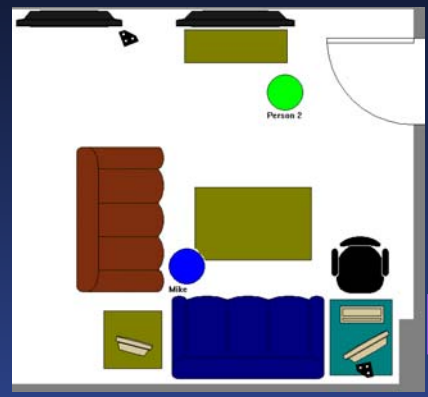
Geometric Model



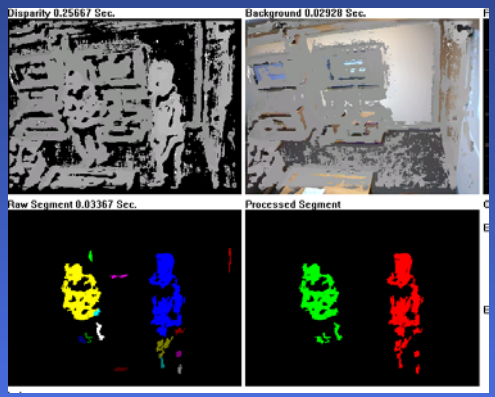
Measurements

Queries

Applications/UIs



Commands



Sensors

Physical World

Actuators

Room Control in EasyLiving

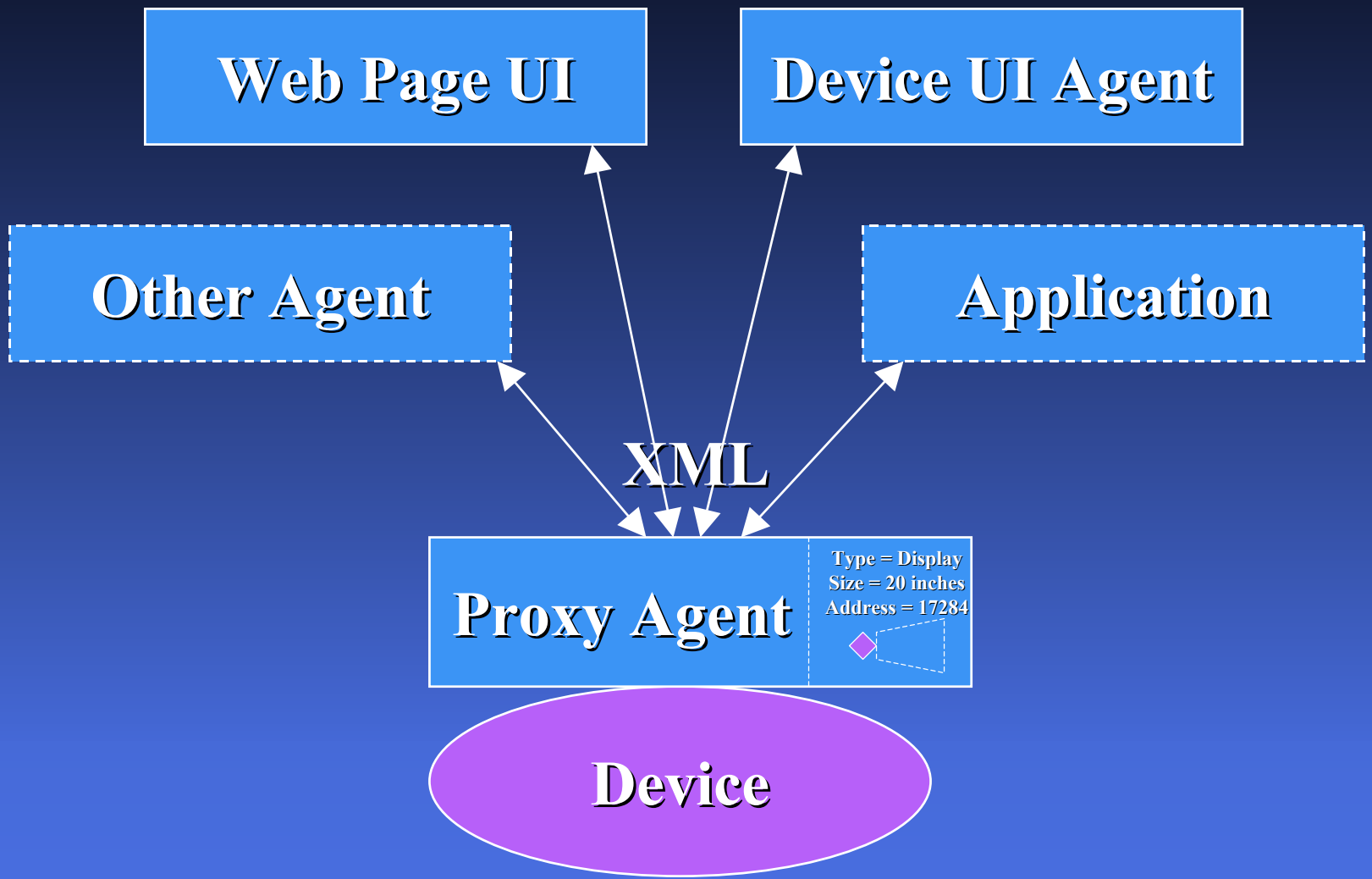
Turning On The Lights

- Flip a switch
- GUI dialog box
- Click on a GUI map
- “Turn on the light by the sofa”
- “Turn on *that* light”
- “I want to read a book”
- Make a funny gesture
- Walk into the room

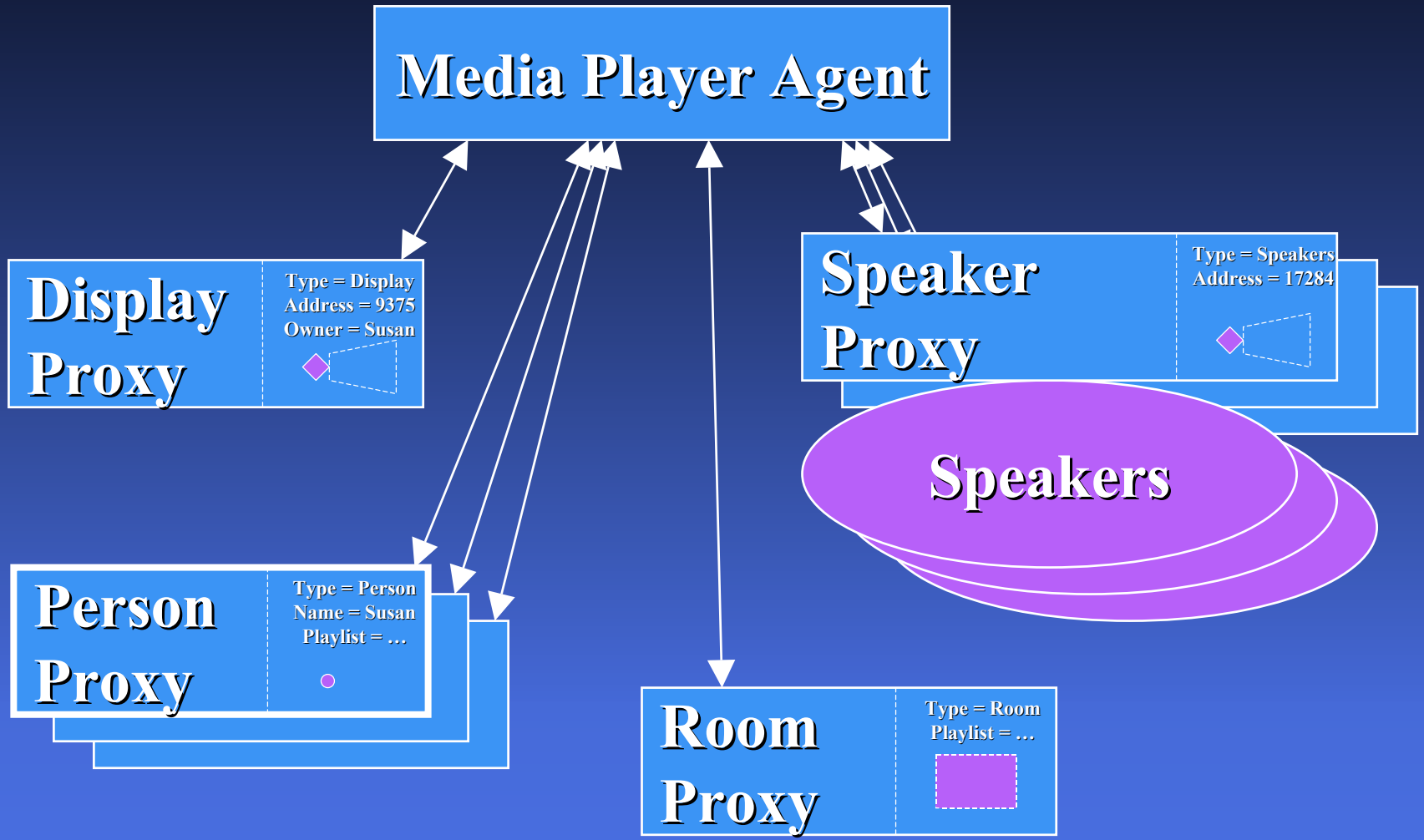
Turning On The Lights – How?

- Flip a switch – hardwired
- GUI dialog box – list (GM)
- Click on a GUI map – GM
- "Turn on the light by the sofa" – speech
- "Turn on *that* light" – multimodal
- "I want to read a book" – infer action
- ~~Make a funny gesture – vision~~
- Walk into the room – automatic

Device Control



EasyLiving Media Player



Automatic Behaviors

Example: Turn on the lights when you enter the room

- Condition ⇒ Action (program)

- Behaviors of the room
- Behaviors of the person

- Automatic behaviors are part of the UI

  (Where do they come from?)

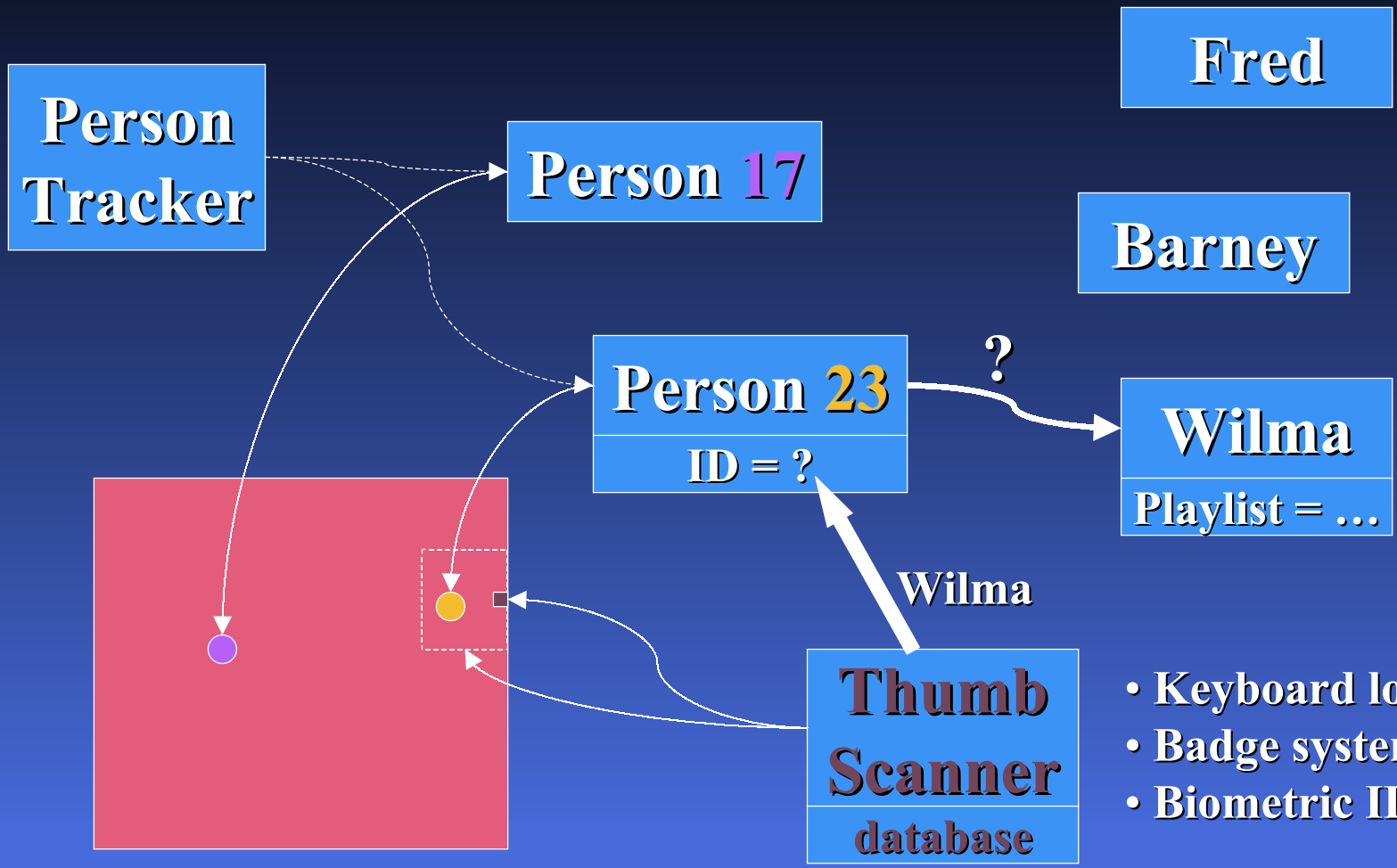
Authentication in EasyLiving

Authenticated or Not?

- When you walk into the room, you are an unknown person
  - Limited privileges:
    Room controls, Web browsing
  - Toolbar appears on the screen

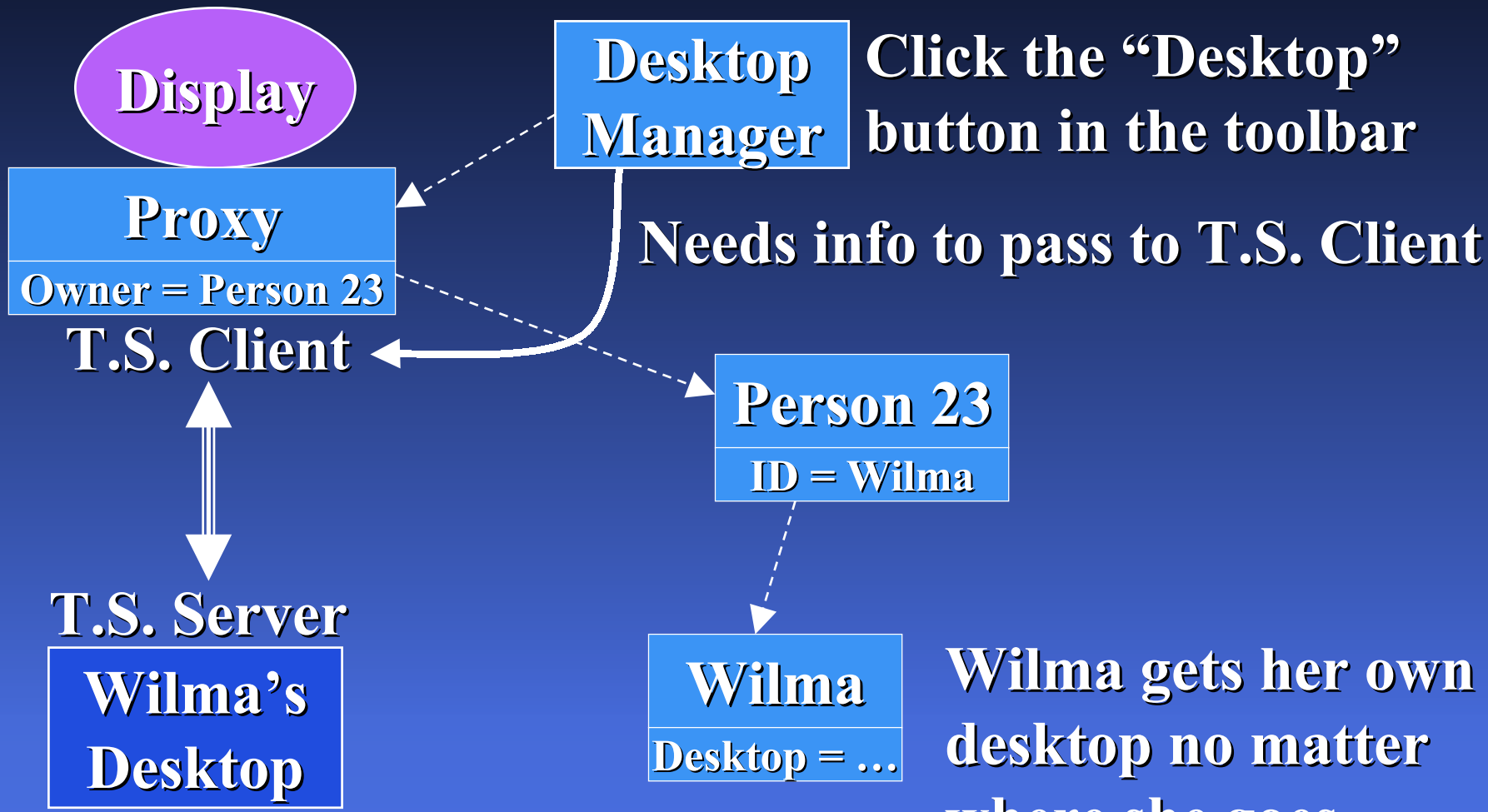
- You can authenticate to become known as a specific individual
  - Greater privileges – desktop
  - Personal data available – playlist

Authentication in EasyLiving



Geometry provides the link

Personal Desktop

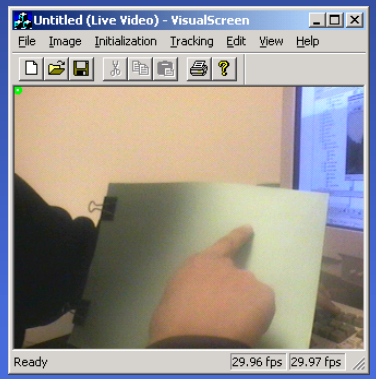


Future Directions for EasyLiving

Vision for Interaction

Pointing at things:
"Put my desktop on *that* display"

Device does not need to be a real object

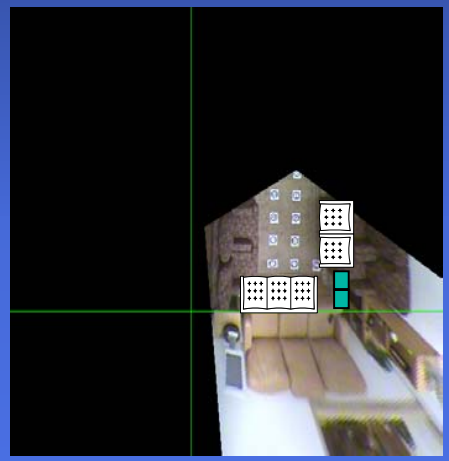


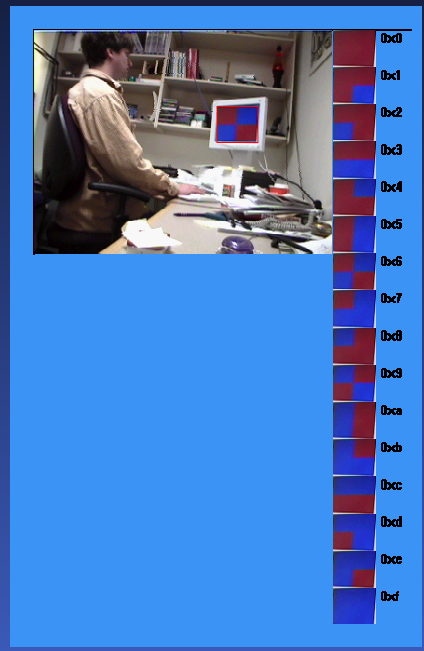
Paper as mouse

Paper keyboard

World Model Building

Build geometric model using drawing program

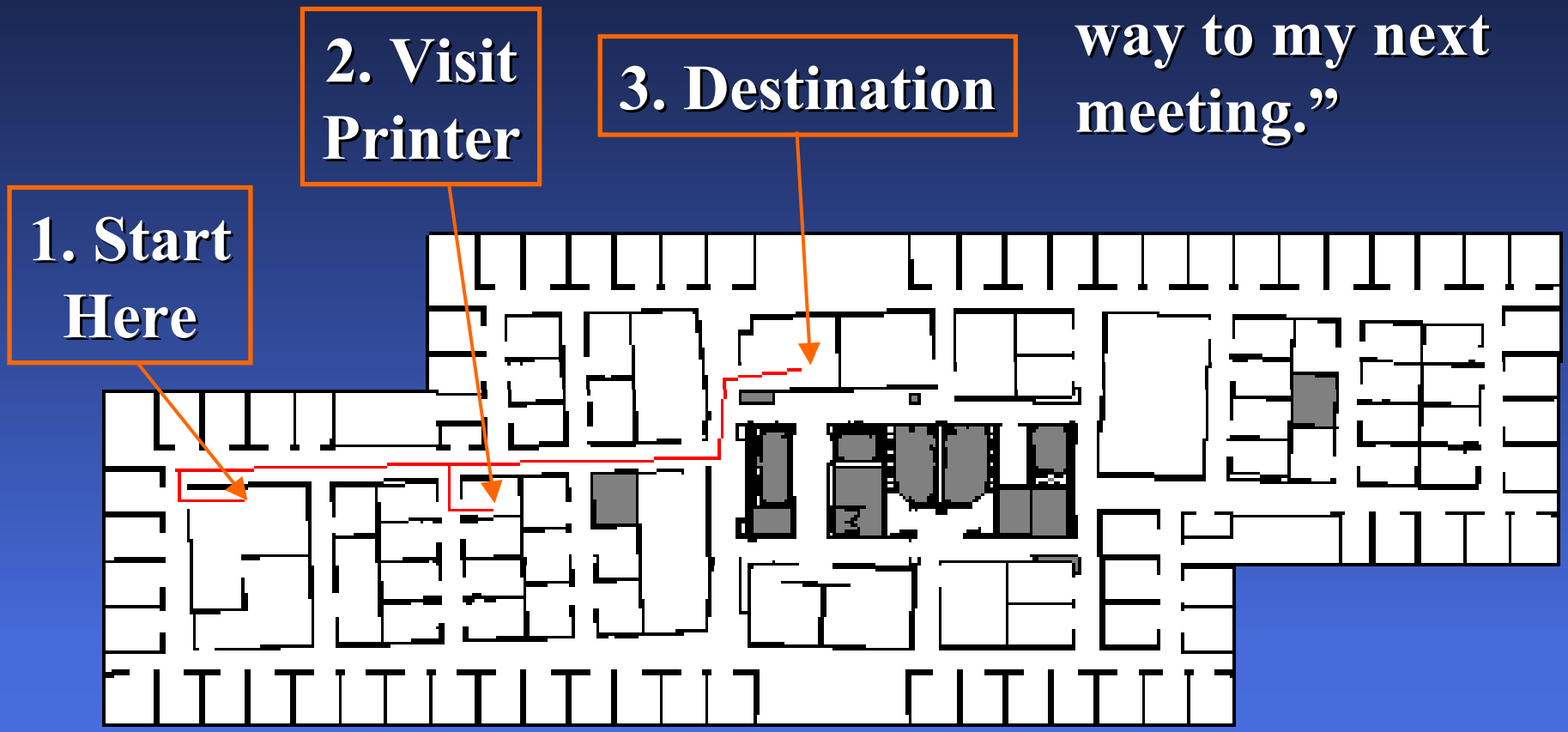




Use cameras to help build model

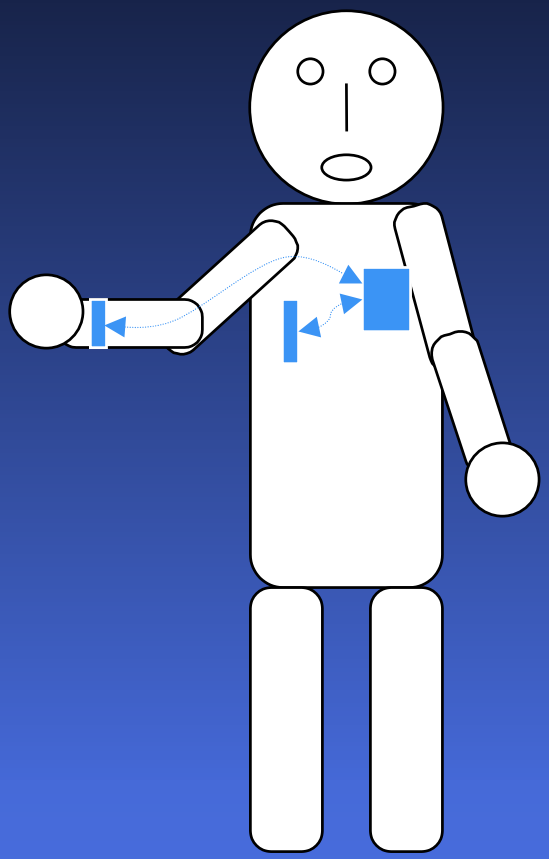
Geometric Path Planner

"I need to print a handout on the way to my next meeting."



(Not yet integrated with geometric model)

“Sidewalk Warrior”



- Novel low-power devices (Turner W.)
  - Watch w/ display
  - Pen w/ accelerometers
- Communicate via BodyNet
- PocketPC as integrator:
  - Pocket EasyLiving
  - Proxies for novel devices
  - Wireless LAN
- Automatic integration with room

Contact Anyone Anywhere